

# **A climatological study of cloud to ground lightning strikes in the vicinity of the Kennedy Space Center**

Lee Burns, Raytheon  
Ryan Decker, NASA

## **Abstract**

Lightning strike location and peak current are monitored operationally in the Kennedy Space Center (KSC)/Cape Canaveral Air Force Station (CCAFS) area by the Cloud to Ground Lightning Surveillance System (CGLSS). The present study compiles ten years of CGLSS data into a climatological database of all strikes recorded within a 20-mile radius of space shuttle launch platform LP39A, which serves as a convenient central point. The period of record (POR) for the database runs from January 1, 1993 to December 31, 2002. Histograms and cumulative probability curves are produced to determine the distribution of occurrence rates for the spectrum of strike intensities (given in kA). Further analysis of the database provides a description of both seasonal and interannual variations in the lightning distribution.

## **Introduction**

Lightning activity in the Kennedy Space Center (KSC) area is monitored continuously by the Cloud to Ground Lightning Surveillance System (CGLSS), which has been in operation since 1990. The system consists of six independent and geographically dispersed lightning detection and direction sensors, a centralized strike position analyzer, and a networked data display. The position analyzer and the data display are collocated in the Range Operations Command Center (ROCC) at Cape Canaveral Air Force Station. The locations of the six sensors, along with the ROCC, are shown in Figure 1. Also shown in Figure 1 is the shuttle launch pad LP39A, which is used as a convenient point of reference for KSC. The current results are then strictly applicable to Shuttle pad and launch operations. However, due to general consistency of the geographical distributions of strikes in the overall region, other areas of KSC should expect similar distributions near strikes over time. Hence the current study is also of interest to other current or future vehicles that do or will launch out of KSC. A ring of 20 miles (32 km) radius, centered on LP39A, is also shown in Figure 1. Only lightning strikes that occurred within this circle are considered in the following analysis. A detailed description of the CGLSS hardware, system capabilities, and operational limitations can be found in the CGLSS Instrumentation Handbook, which is available online at [http://www-sdd.fsl.noaa.gov/RSA/cglss/CGLSS\\_inst\\_handbook.pdf](http://www-sdd.fsl.noaa.gov/RSA/cglss/CGLSS_inst_handbook.pdf).

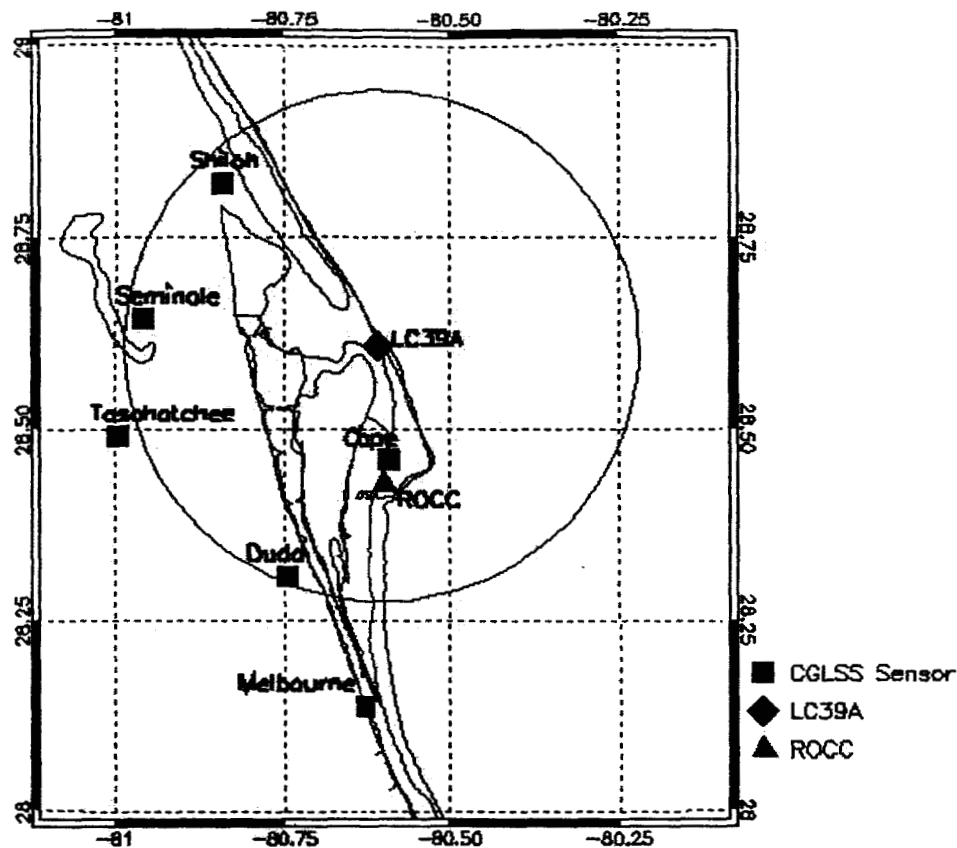


Figure 1. Map of the KSC area showing locations of the CGLSS sensors and the ROCC, along with LP39A. Also shown is a circle of 20-mile (32 km) radius, centered on LP39A.

The collected CGLSS data is operationally archived for the ongoing period from January 1, 1990 to the present. The data is stored in tabular ASCII format, and is available online at <ftp://trmm.ksc.nasa.gov/mids/LLP/>. After obtaining all data for the 10-year Period of Record (POR, January 1, 1993 to December 31, 2002), a database subset was developed consisting of all lightning strikes that occurred within 20 miles (32 km) of KSC. For convenience, LP39A was used as a specific positional surrogate for KSC. The original inclusive database contains in excess of 1.5 million lightning strikes. The subset database contains 173039 individual strikes.

## Results

A histogram of lightning strike intensities (in kA) was produced for all strikes in the subset database, for the entire POR, as shown in Figure 2. The mean magnitude of all strikes was 26.0 kA with a standard deviation of 20.2 kA. In Figure 2, the y-axis is scaled logarithmically to enhance detail at low occurrence values.

Figures 3-12 show similar histograms of strike intensities for each individual year in the POR. Figures 13-24 show histograms of strike intensities for each month, including all strikes that occurred during that month for all years in the POR.

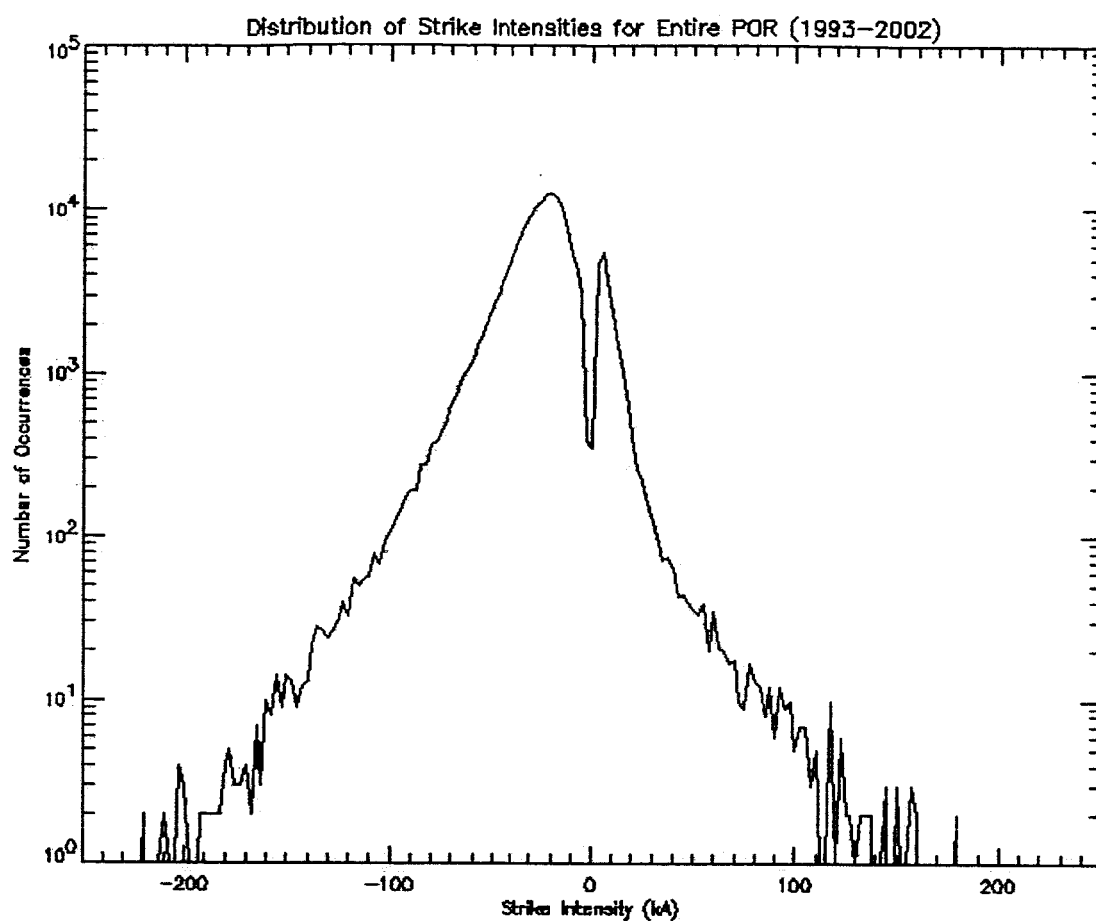


Figure 2. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for the entire POR, from January 1, 1993 to December 31, 2002.

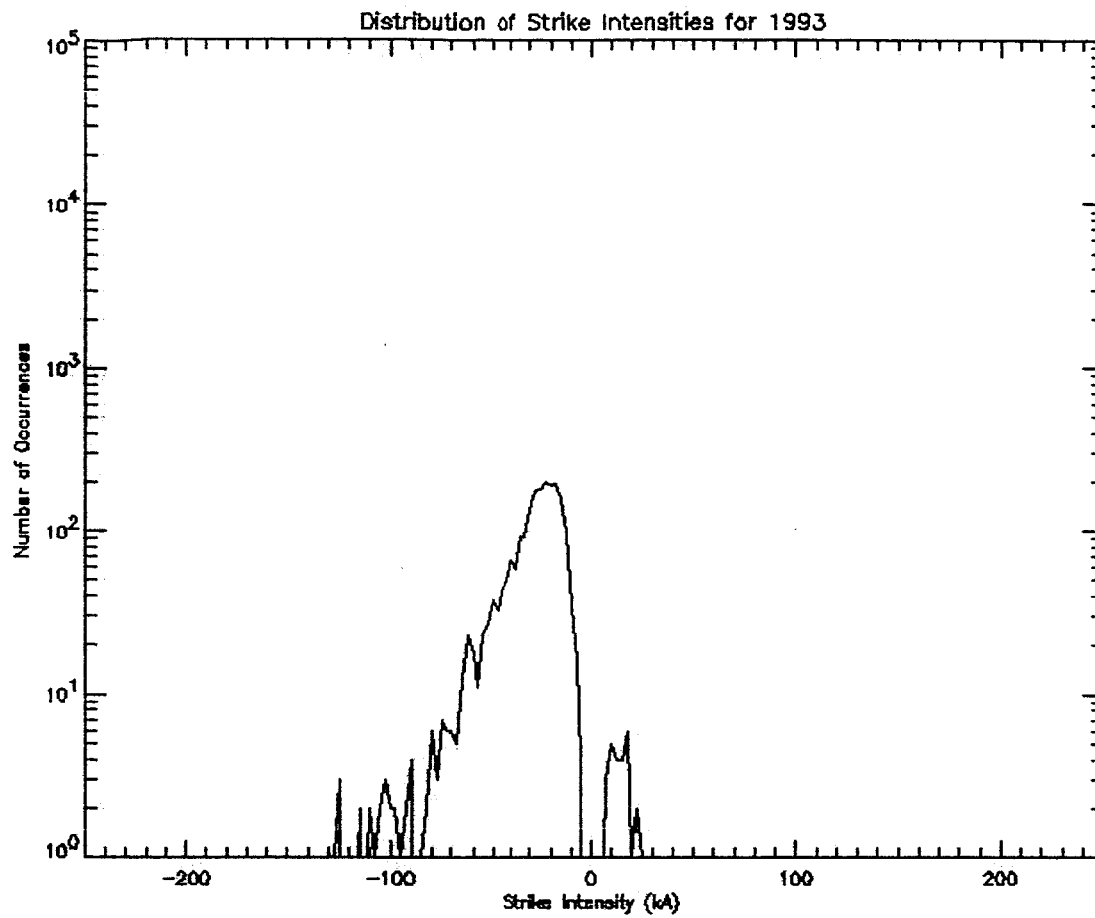


Figure 3. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A during the year 1993.

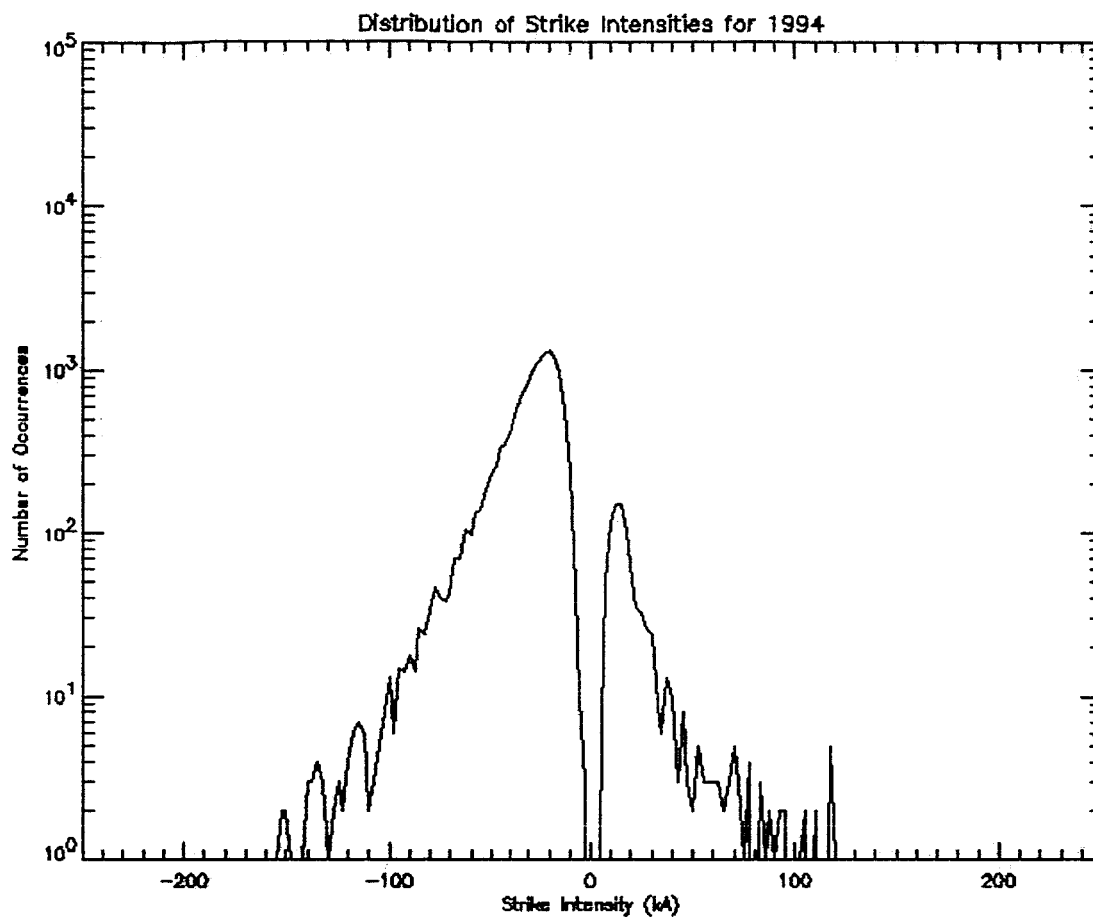


Figure 4. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A during the year 1994.

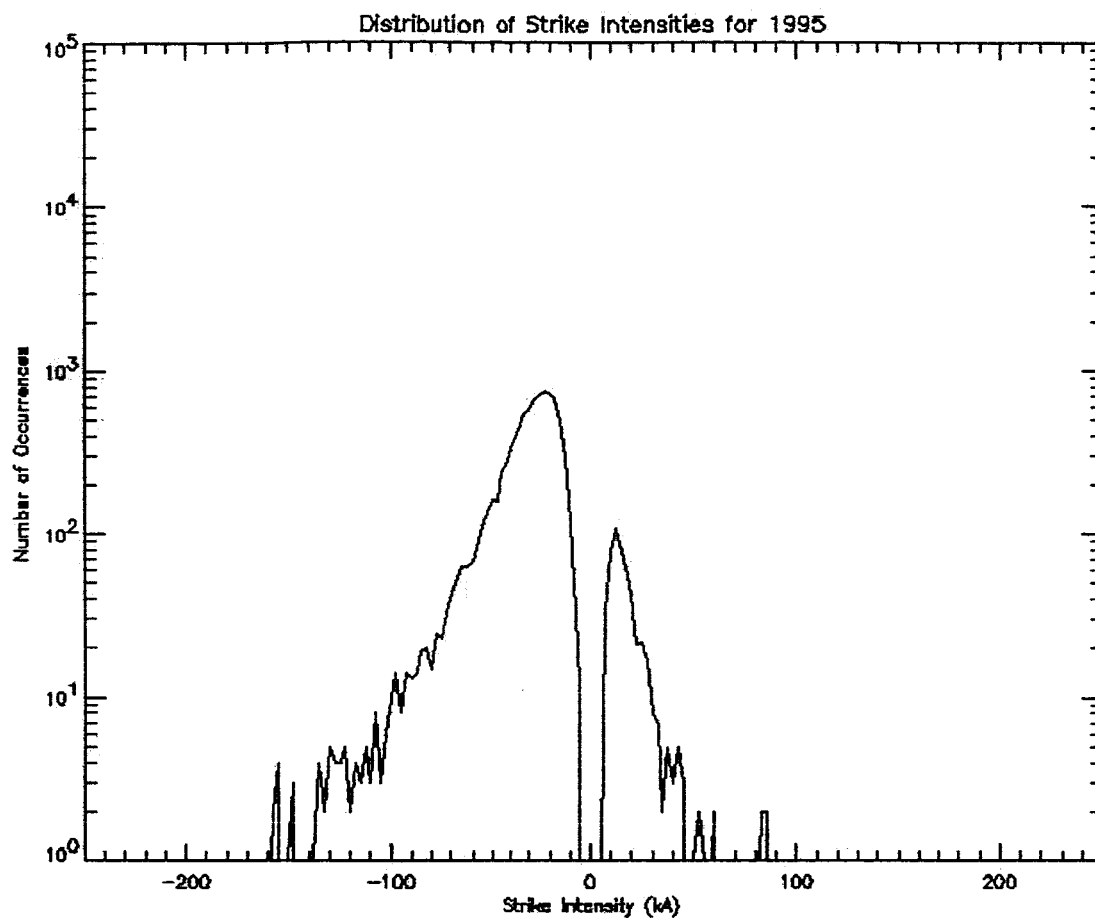


Figure 5. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A during the year 1995.

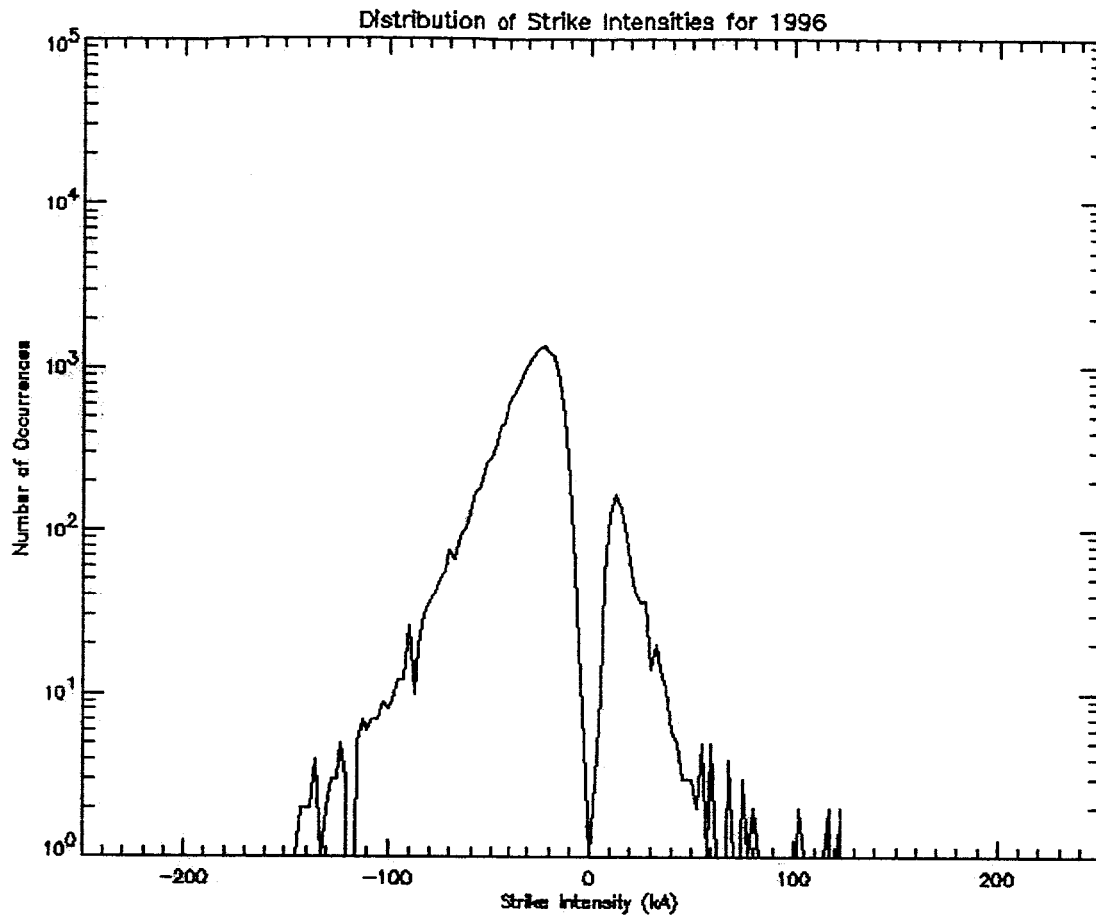


Figure 6. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A during the year 1996.

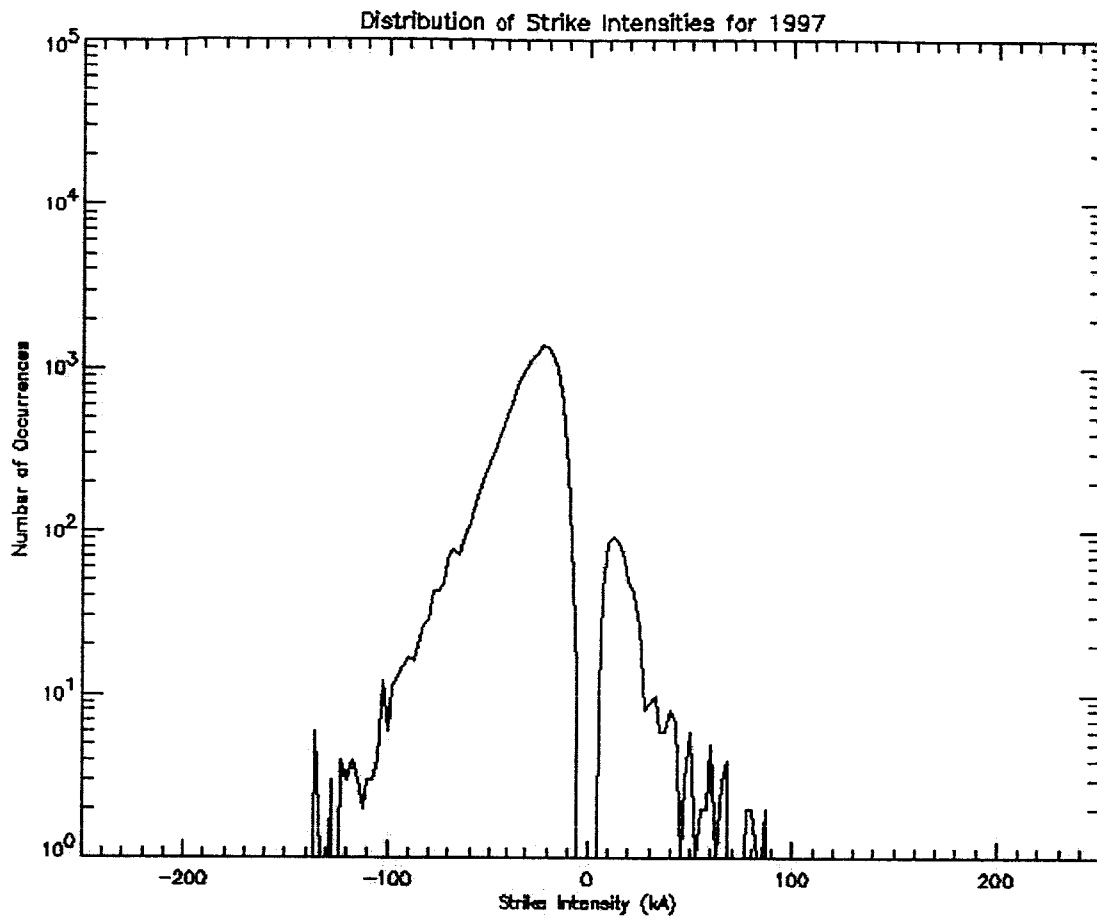


Figure 7. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A during the year 1997.



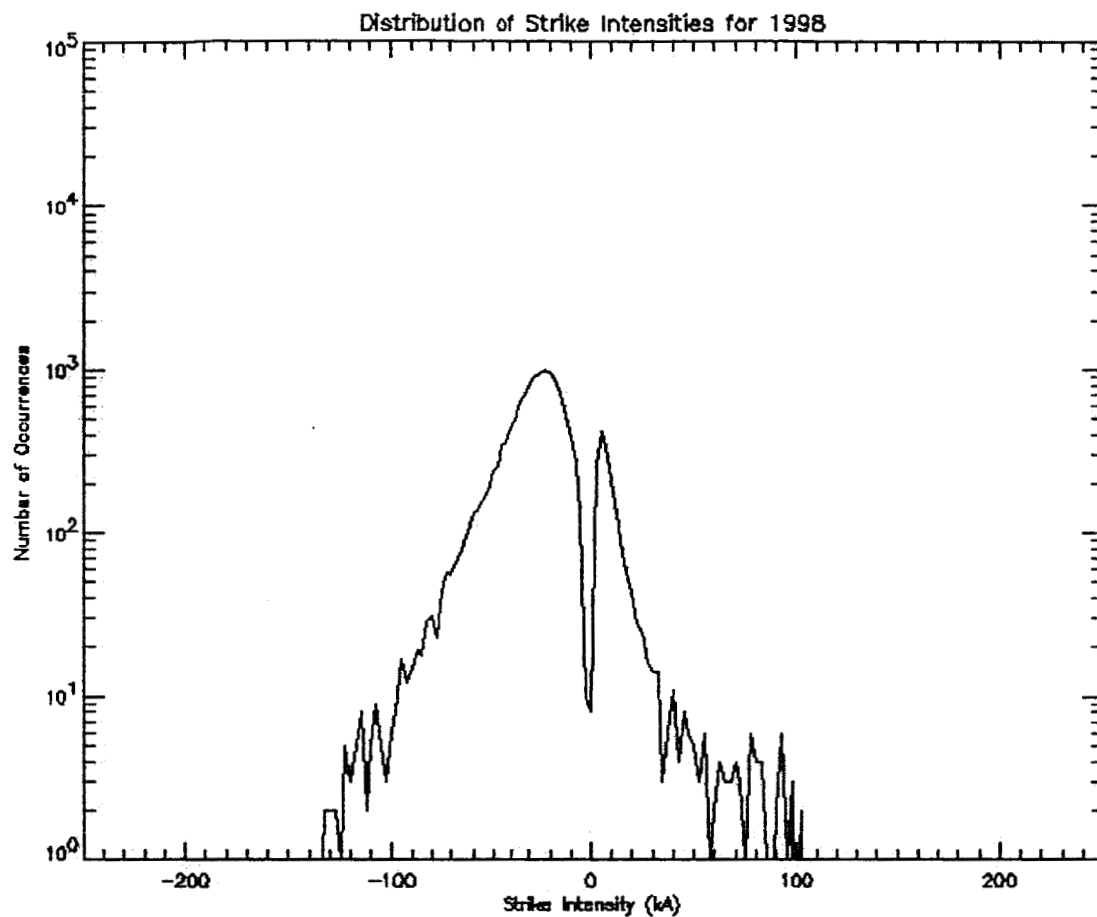


Figure 8. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A during the year 1998.

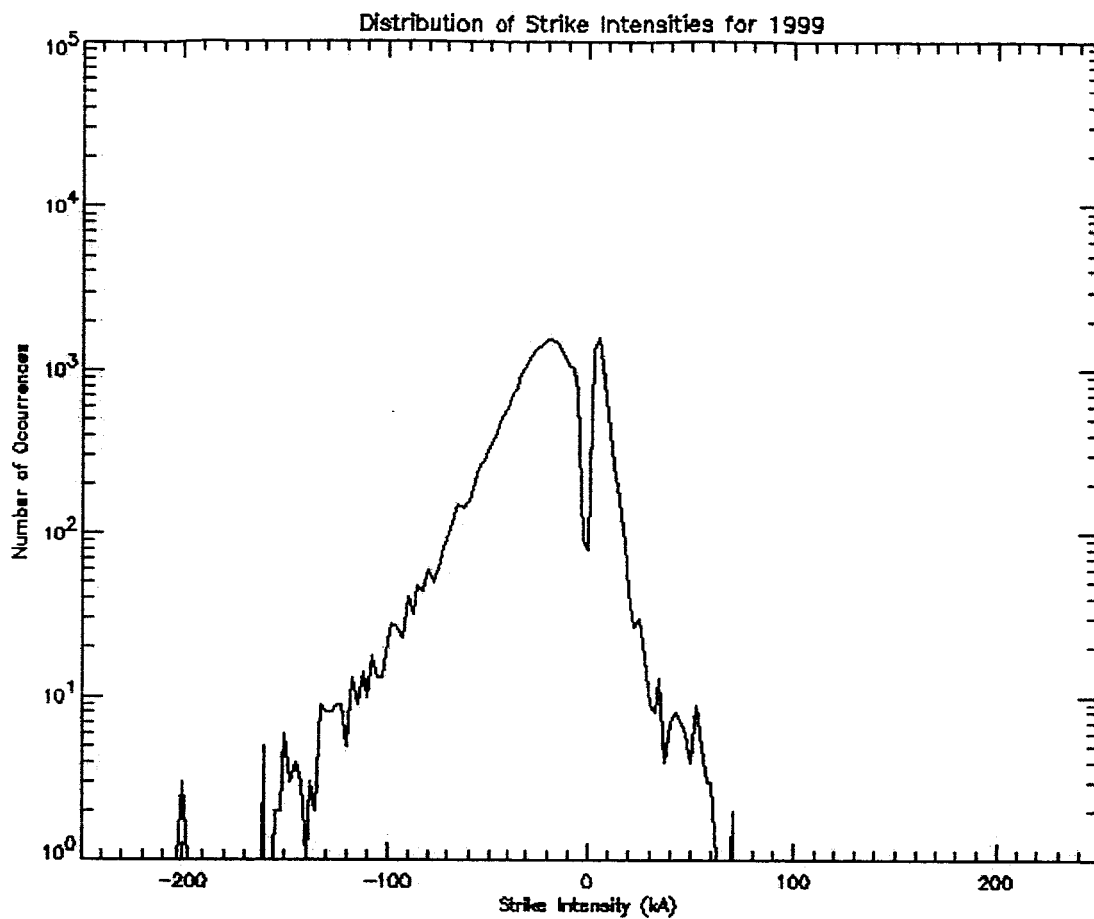


Figure 9. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A during the year 1999.

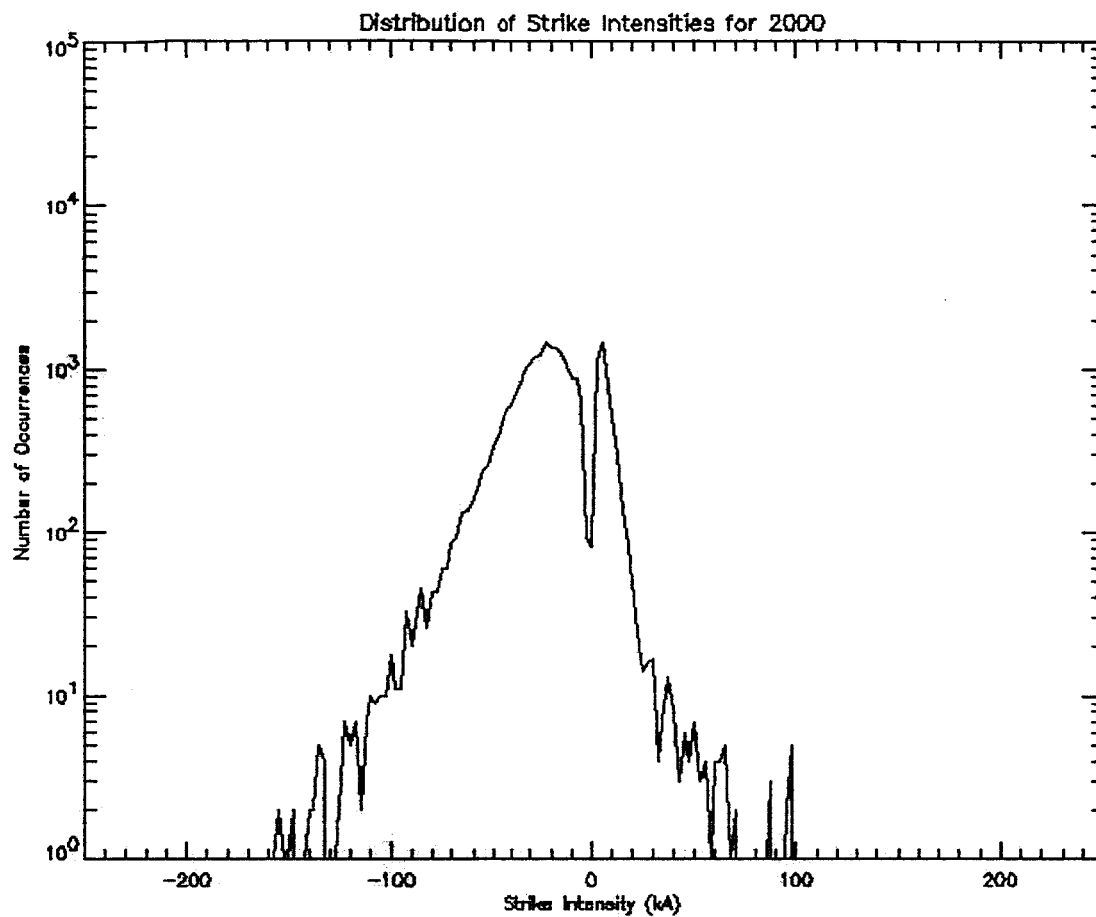


Figure 10. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A during the year 2000.

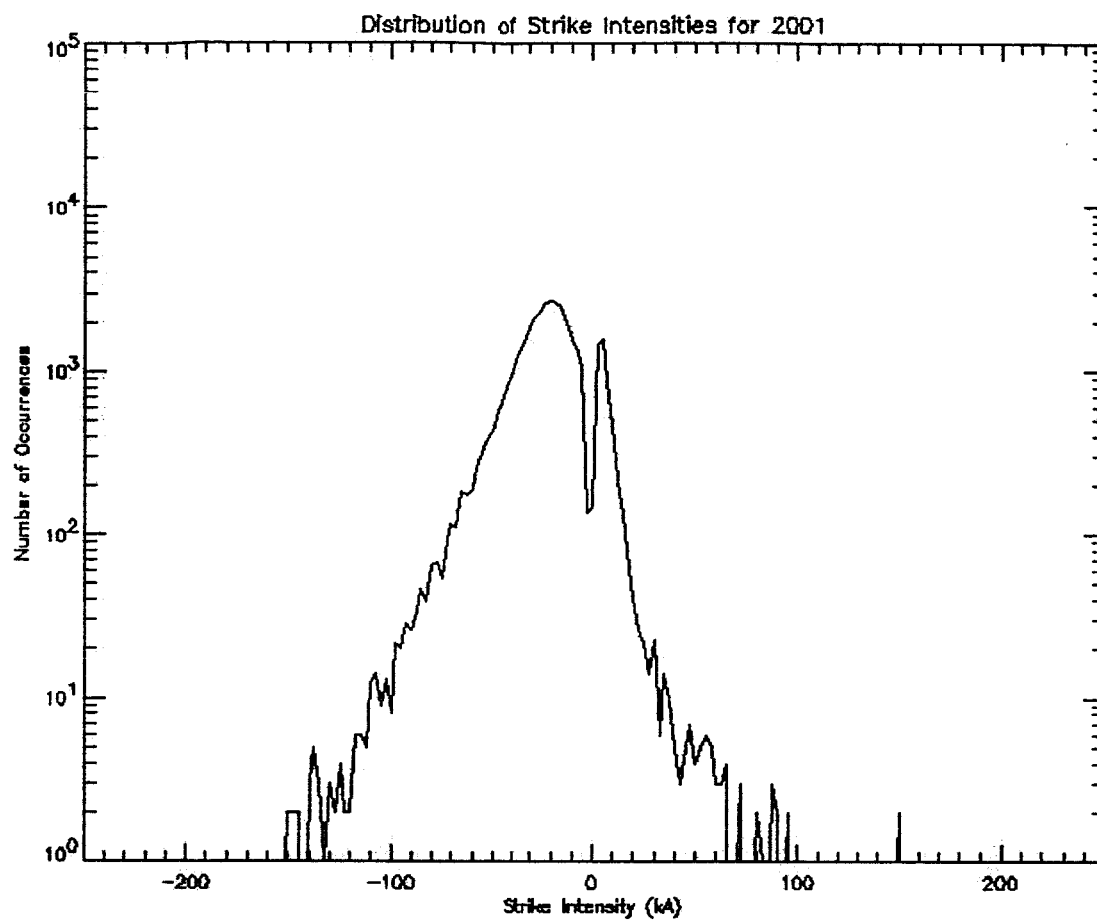


Figure 11. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A during the year 2001.

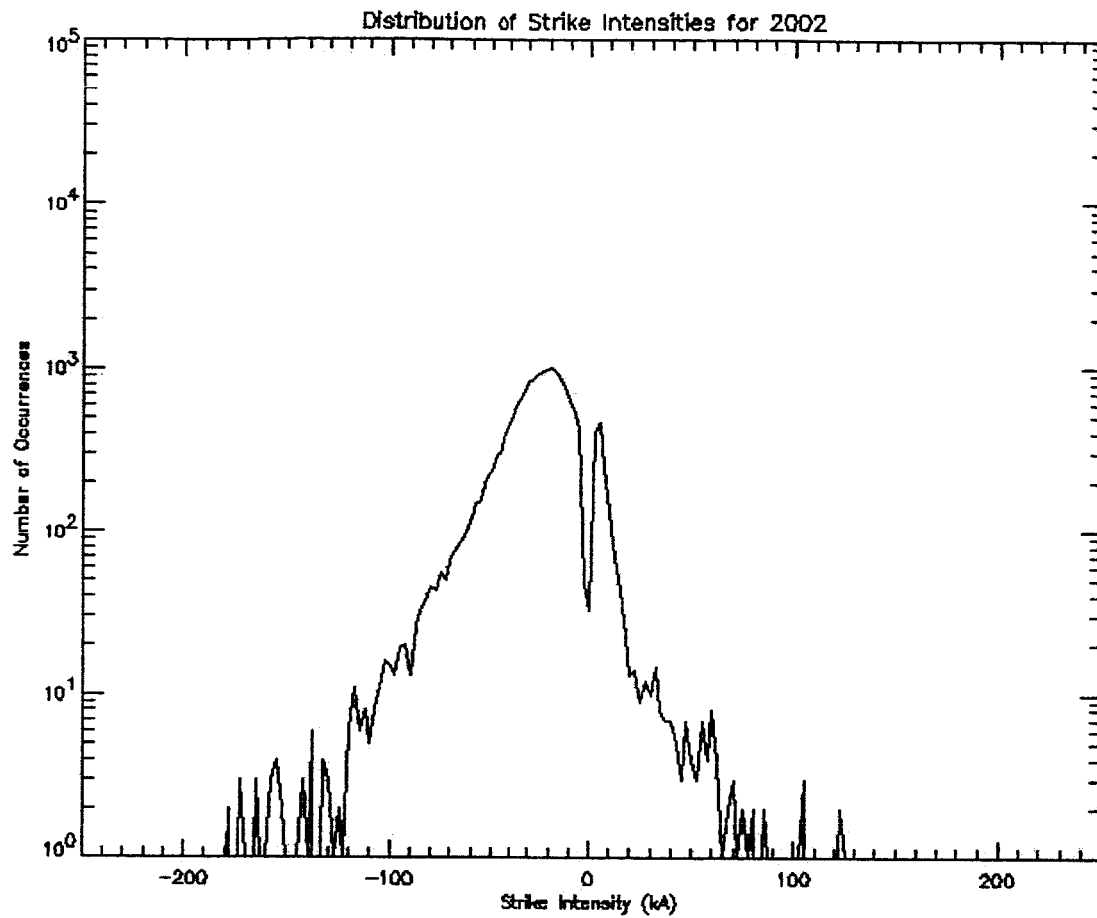


Figure 12. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A during the year 2002.

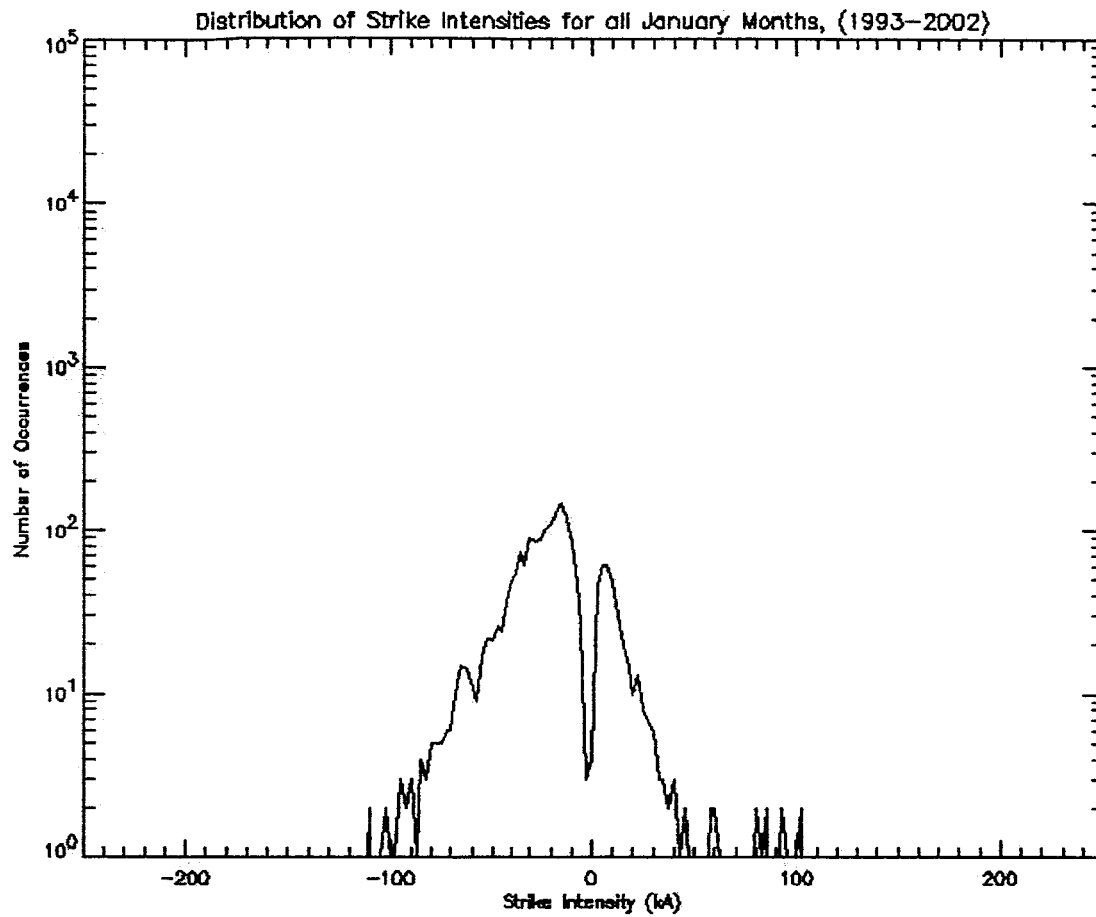


Figure 13. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for all January months in the POR.

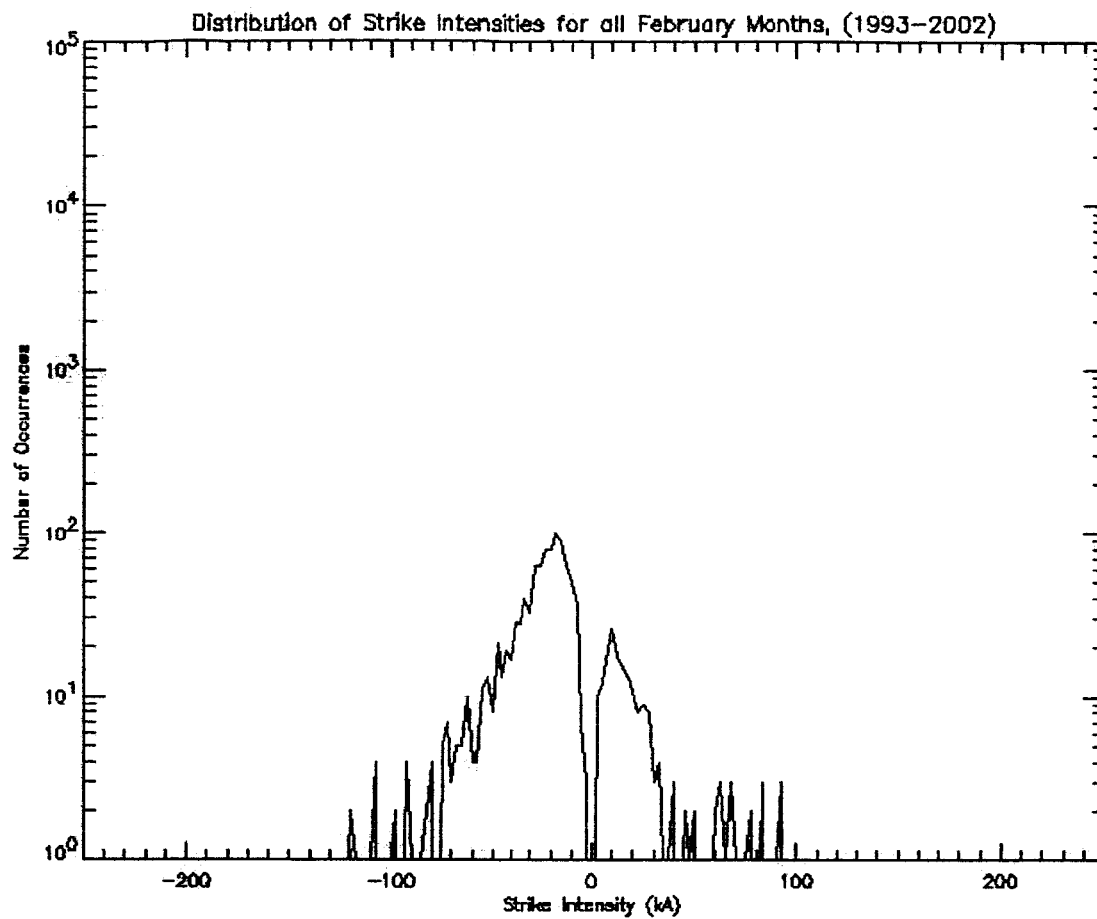


Figure 14. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for all February months in the POR.

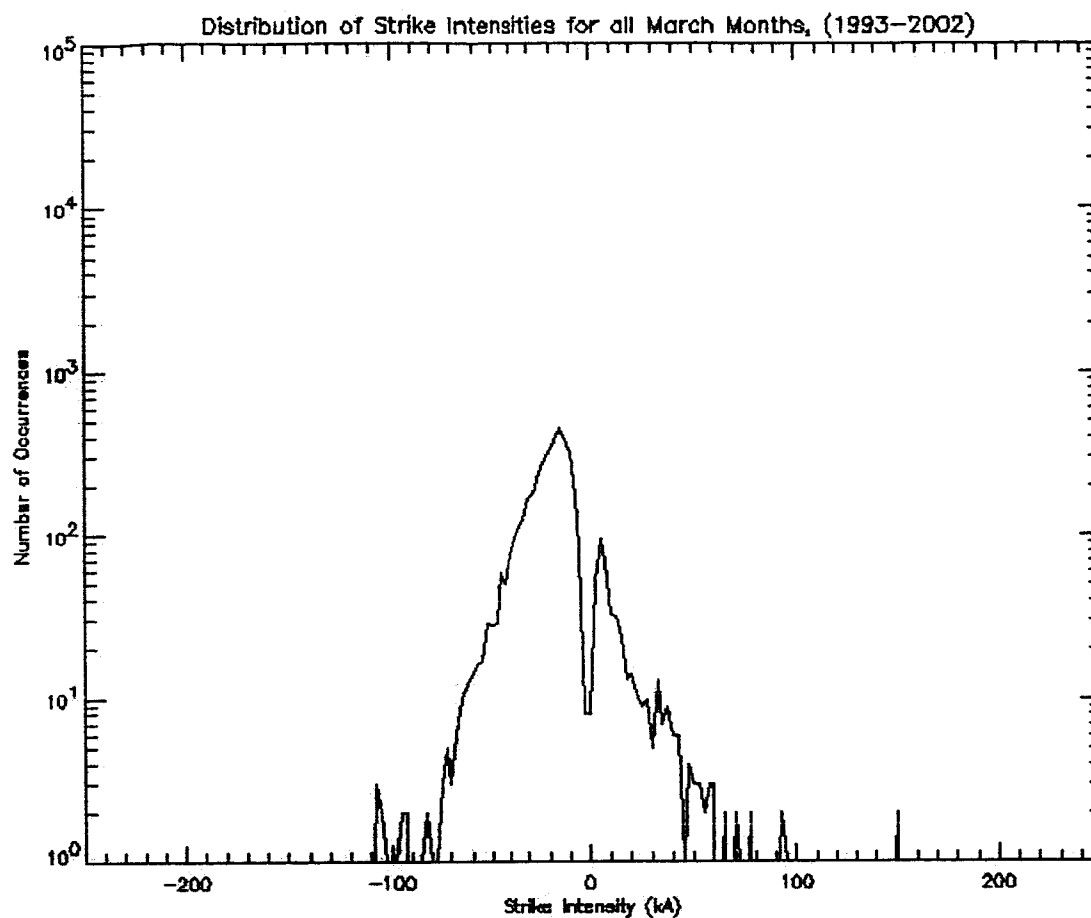


Figure 15. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for all March months in the POR.



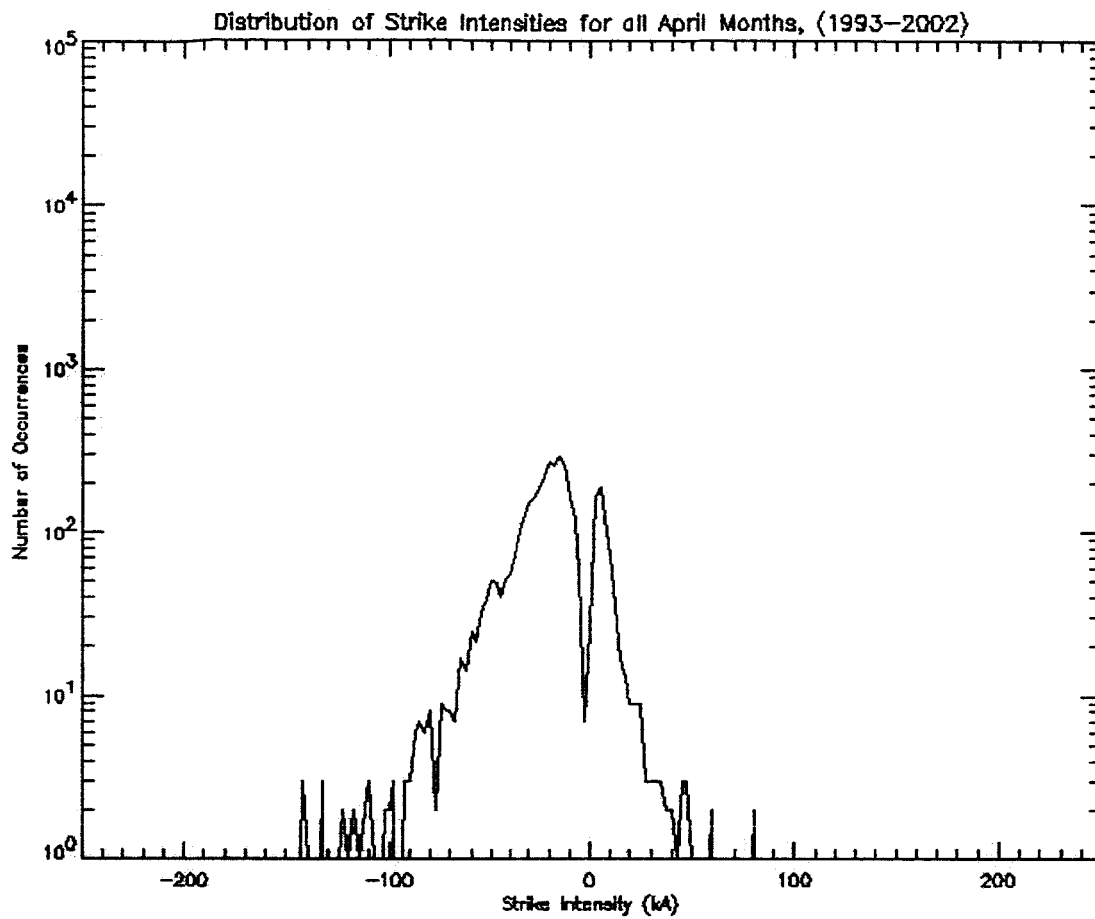


Figure 16. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for all April months in the POR.

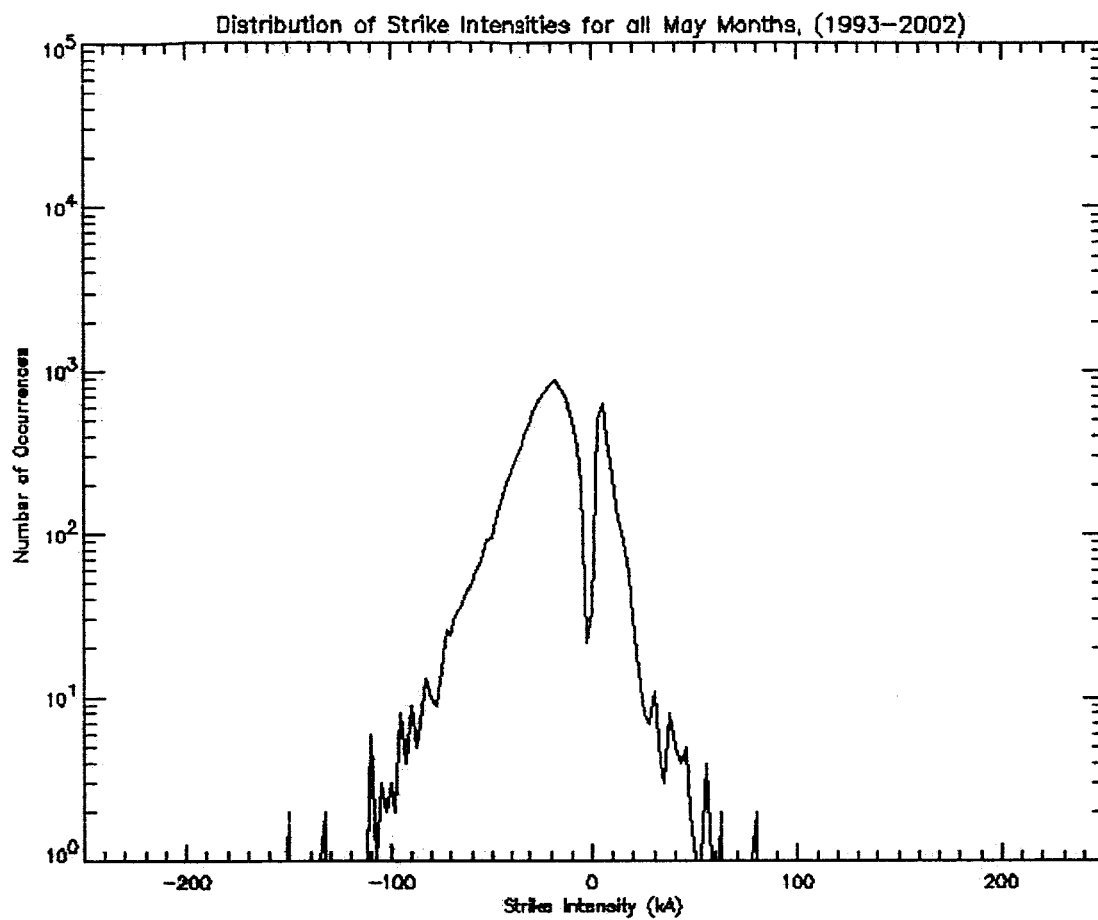


Figure 17. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for all May months in the POR.

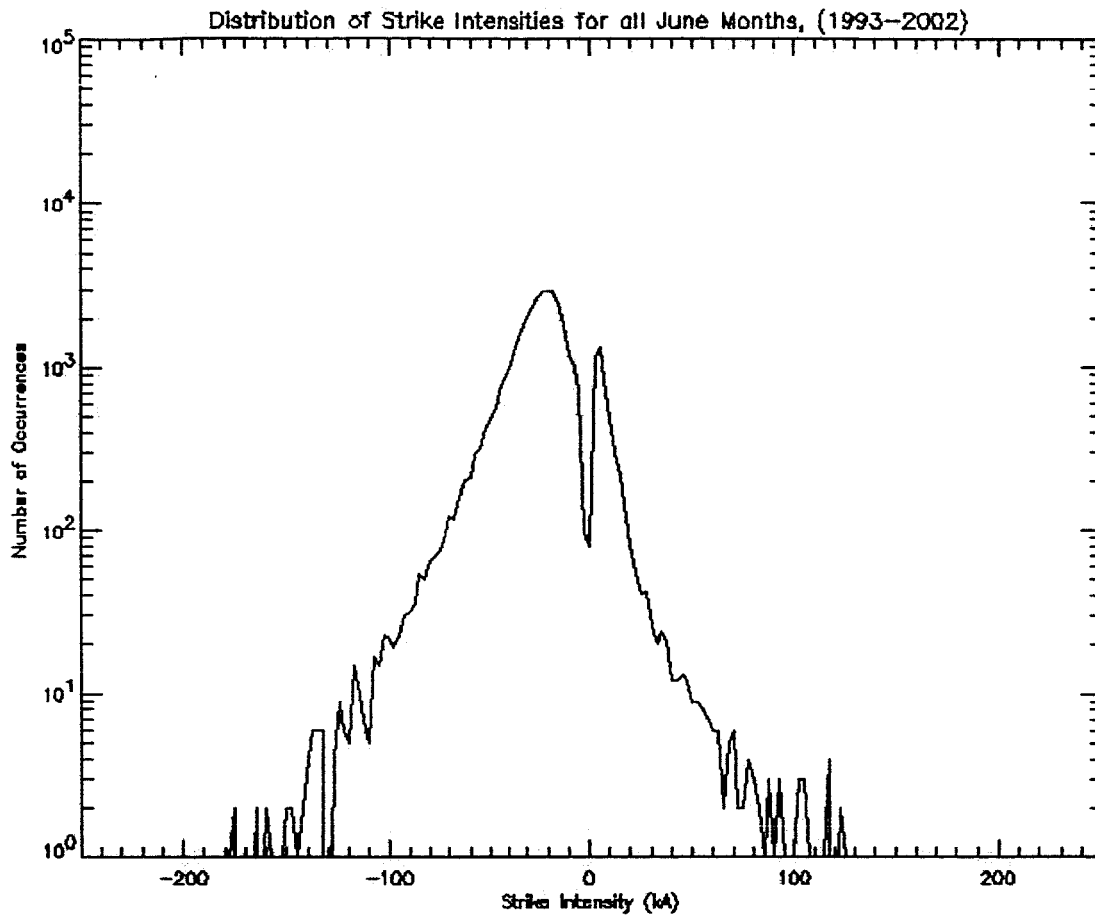


Figure 18. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for all June months in the POR.

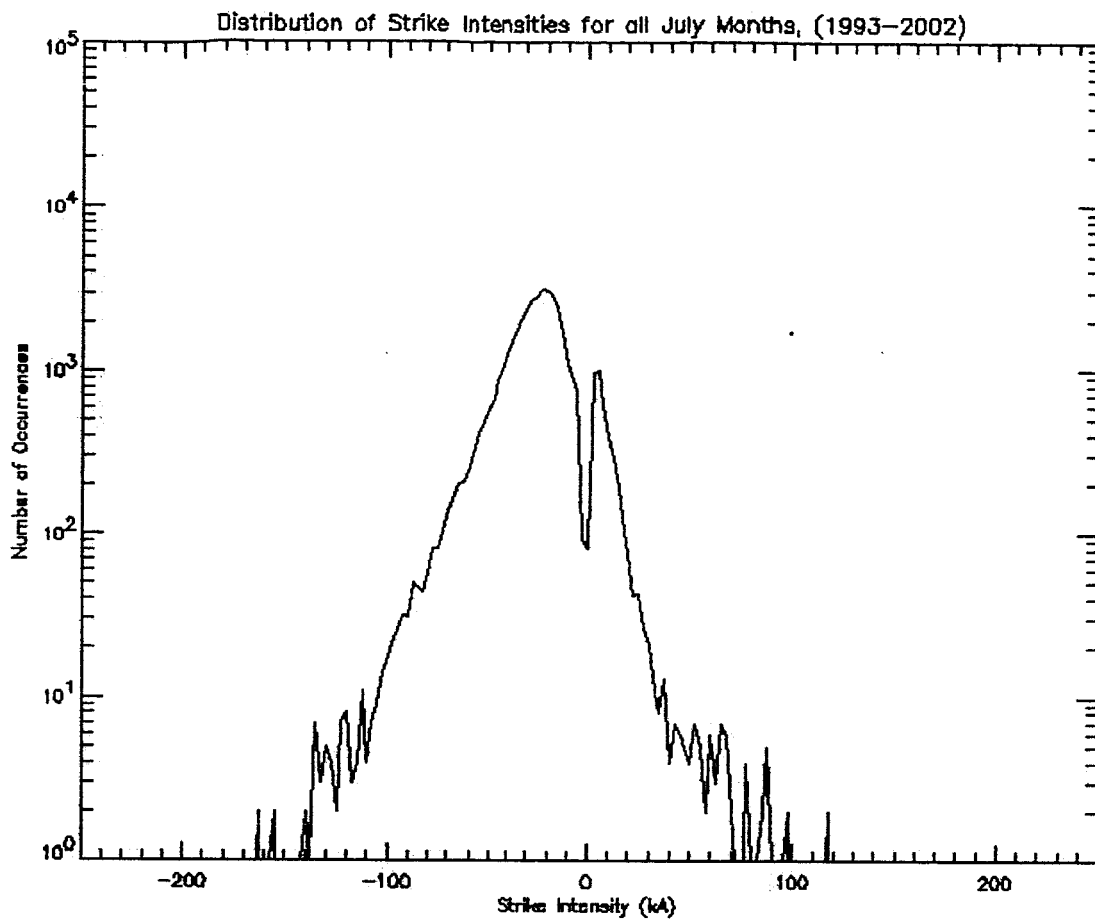


Figure 19. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for all July months in the POR.

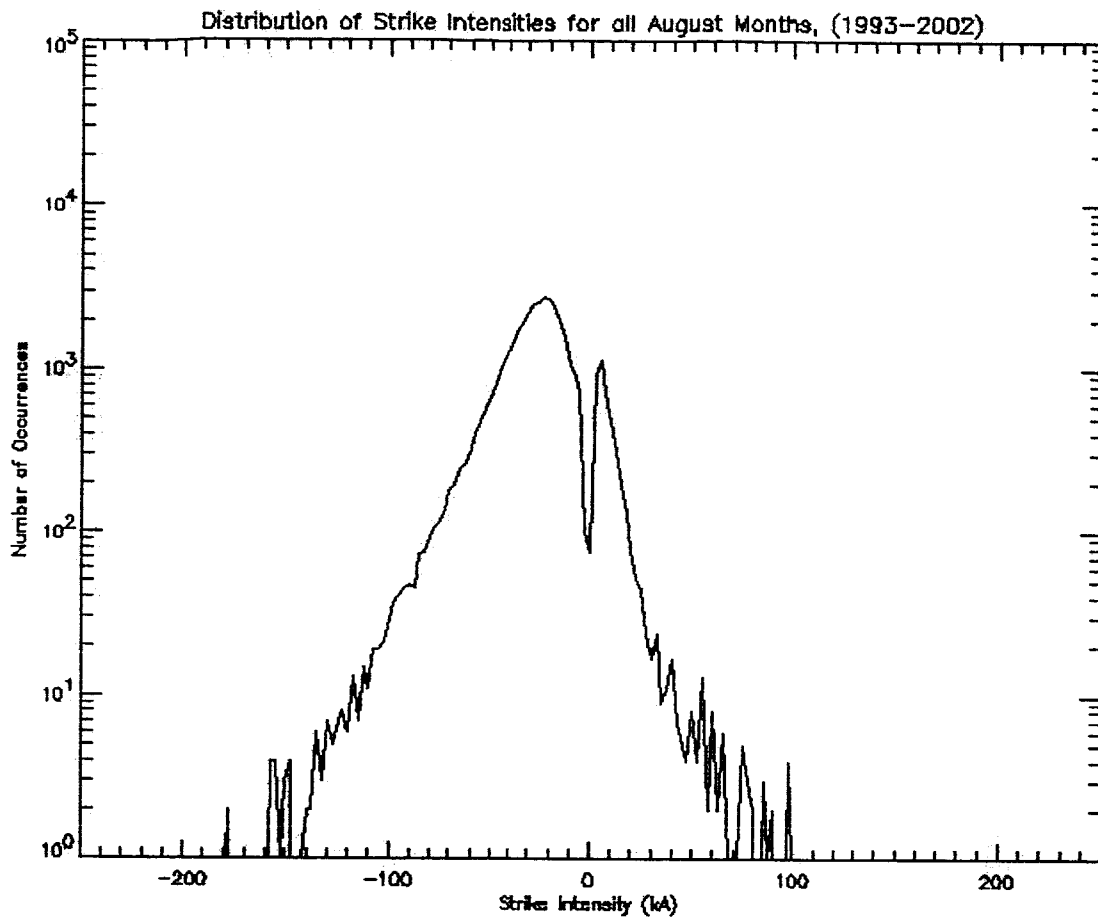


Figure 20. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for all August months in the POR.

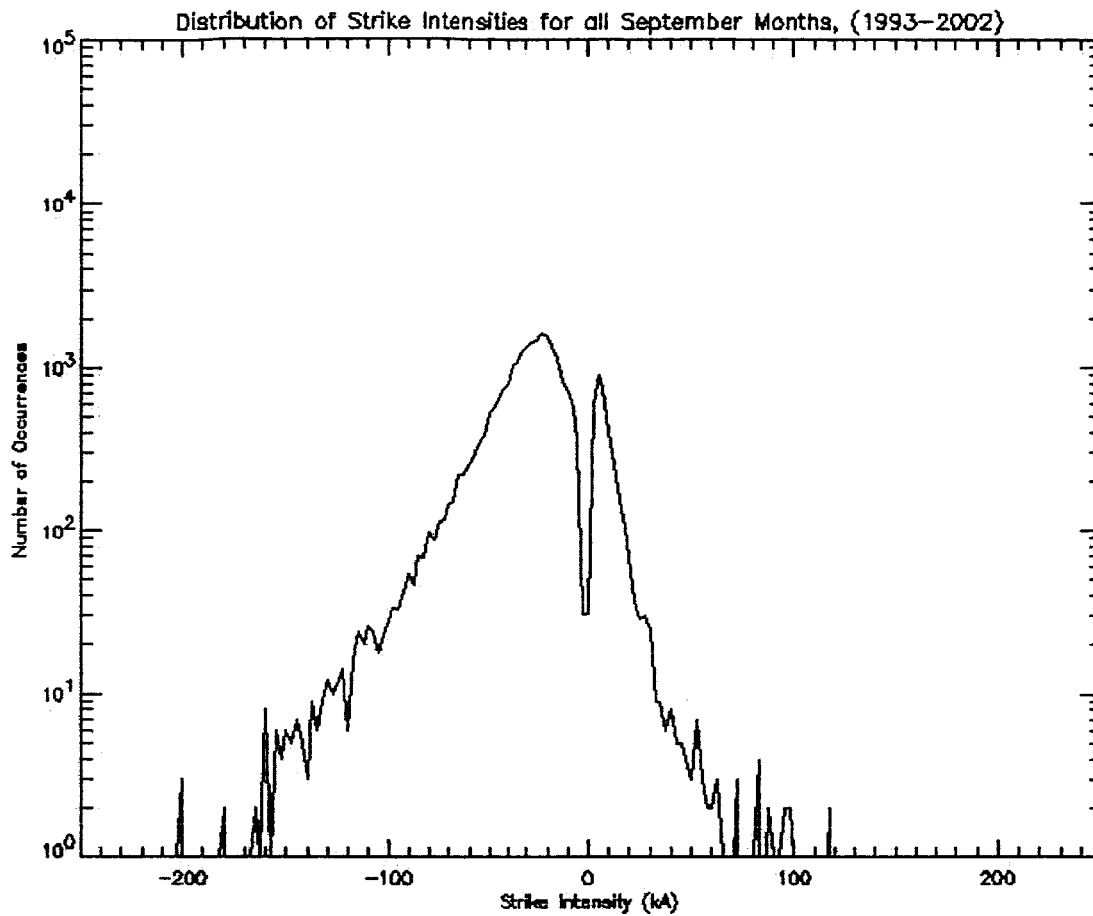


Figure 21. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for all September months in the POR.

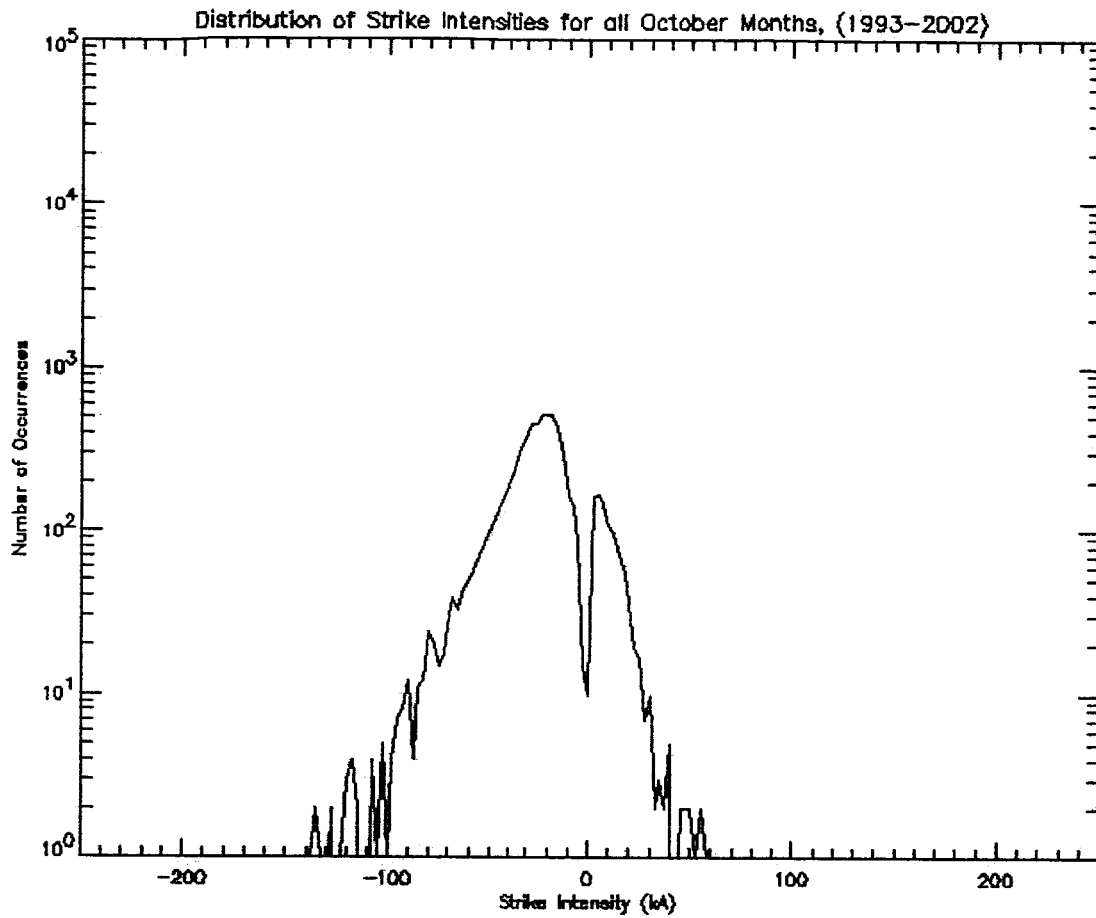


Figure 22. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for all October months in the POR.

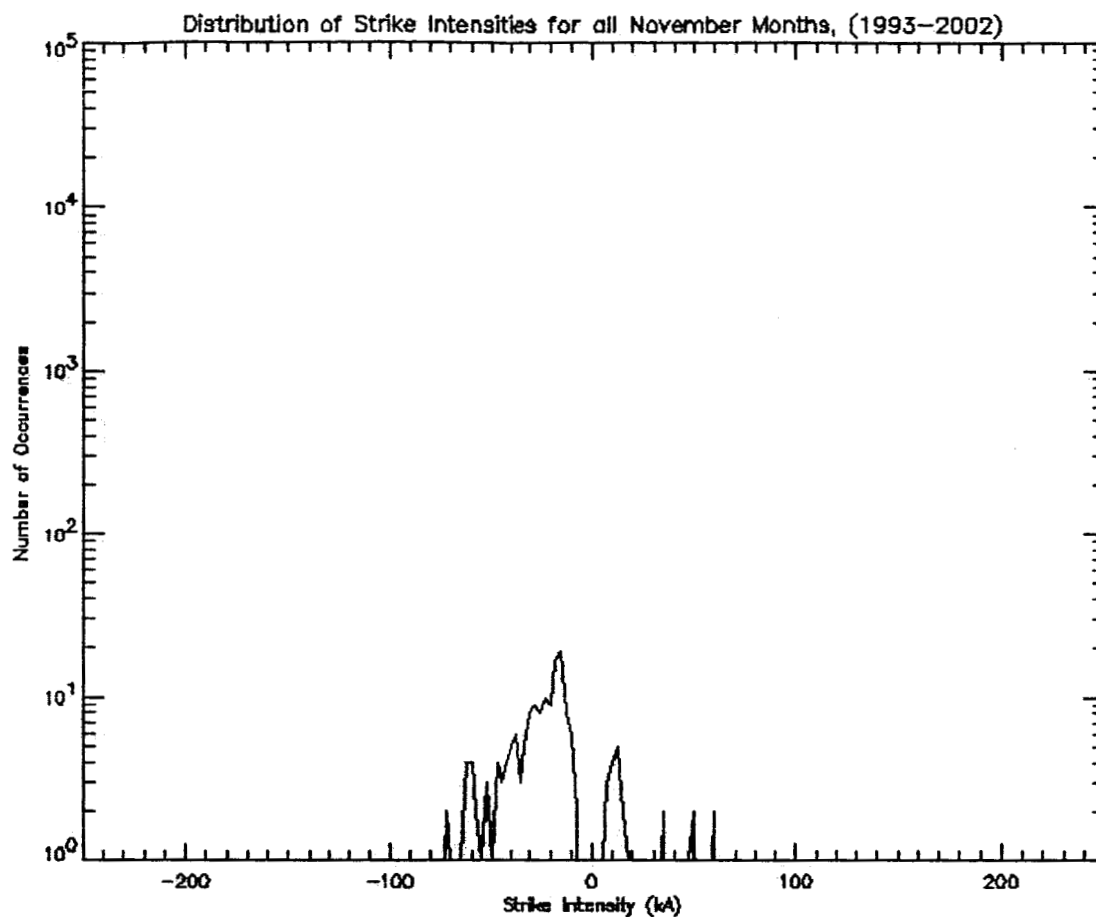


Figure 23. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for all November months in the POR.



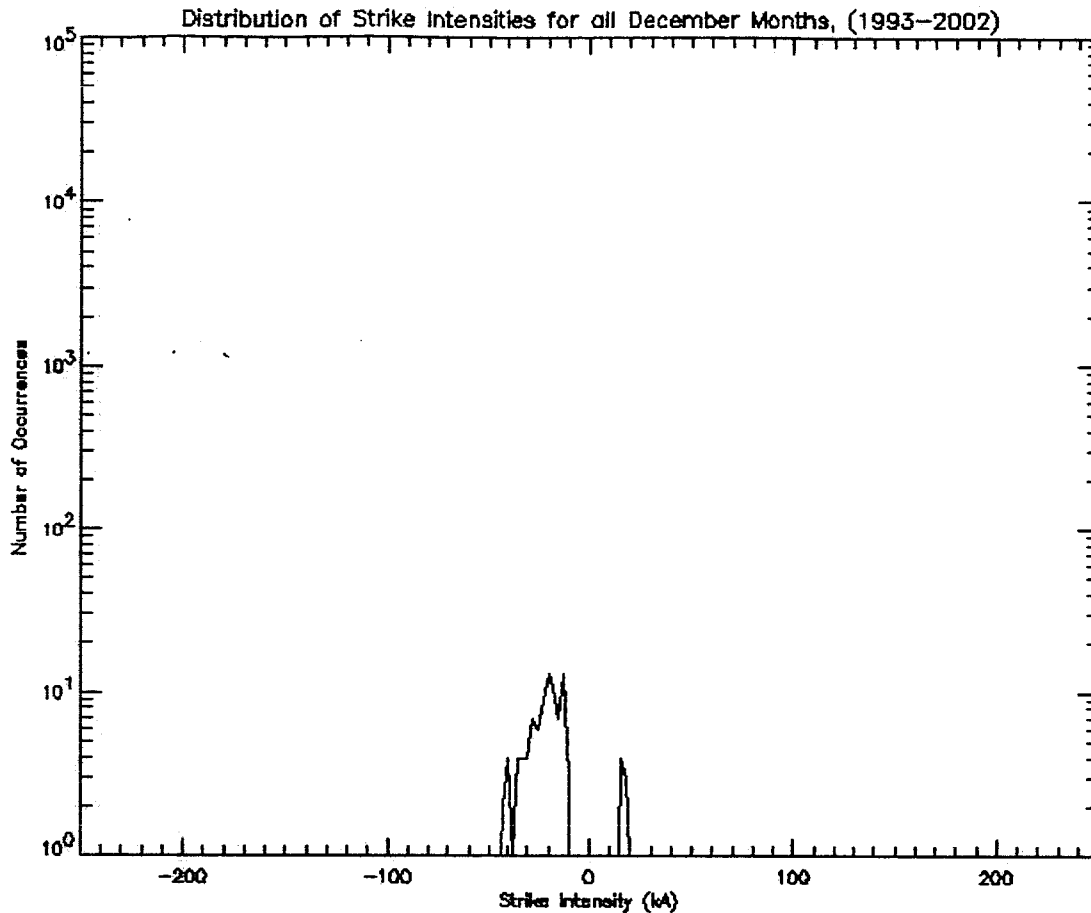


Figure 24. Histogram of lightning strike intensities for all strikes occurring within 20 miles (32 km) of LP39A for all December months in the POR.

As is evident from the figures, there is significant variability in both the monthly and interannual strike distributions. It was expected to find such variability in the monthly values, as the general weather patterns at KSC are known to follow fairly ordered seasonal patterns. However, the degree of interannual variability was unexpected. Table 1 presents the total number of strikes for each month and each year in the POR. The table also gives the annual, and monthly mean strike counts, as well as the standard deviations.

Table 2 gives the magnitude of the strike intensities that correspond to various cumulative probability limits. For example, from the table, on an annual basis, there is a 95% probability that a given strike will have an intensity magnitude less than or equal to 58.4 kA.

### Summary

The distribution of cloud to ground lightning strikes at KSC shows significant variability on both a monthly and interannual basis. For the POR, the greatest monthly strike count occurred in June 2001. Many individual months had no recorded strikes within a 20-mile radius of LP39A, with these occurring typically in the Winter months. On a monthly strike rate basis, July had the greatest average number of strikes with 4042 per month, while December had the lowest average

with only 12 strikes per month. On an interannual basis, 2001 had the greatest average strike rate with an average of 3142 strikes per month, while 1993 had the lowest average strike rate with only 173 strikes per month.

Cumulative probabilities values have been calculated to show what limiting strike magnitudes correspond to various probability limits. These values have implications for various engineering and design applications where knowledge of expected strike magnitudes, given that a strike has occurred, is relevant.

Table 1. Strike count statistics for both monthly and yearly time periods.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Jan	0	2	131	164	594	99	869	0	8	39	1906	191	298																				
Mar	0	1	1	0	0	672	341	24	1	113	4212	421	585																				
May	0	132	98	30	0	423	268	365	1594	1302	11284	1128	1987																				
Jul	0	753	0	79	157	2	650	877	857	267	40419	4042	2873																				
Sep	0	956	0	0	1197	675	6623	658	1073	102	25430	2543	2335																				
Nov	1580	2518	600	5864	2034	1538	4120	3218	13761	3197	181	18	27																				
	17	3083	6011	1200	5051	3204	2643	8363	8510	2337																							
	0	1847	1898	4015	5538	4588	5829	2858	6950	5711																							
	317	1904	290	4218	292	2373	4053	7590	3367	1026																							
	160	2967	0	22	228	380	510	7	1509	1226																							
	0	0	1	0	50	0	8	32	77	13																							
	0	2	0	0	107	0	0	0	0	7																							

Table 2. Strike Intensity Magnitudes for Various Cumulative Probability Limits.

	1990 Period											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	203.6	591.9	594.1	142.4	121.9	138.6	126.3	138.8	158.8	151.0	144.3	145.9
1991	98.9	493.4	105.3	88.8	73.7	84.0	80.0	88.1	106.1	87.5	104.2	98.8
1992	83.6	125.9	66.4	73.7	63.6	70.6	68.5	75.7	87.0	75.1	89.3	91.7
1993	62.9	78.9	49.2	55.0	49.9	55.1	55.3	60.2	67.3	58.5	68.0	74.2
1994	48.4	55.9	38.9	44.9	40.7	40.7	45.8	49.5	54.1	47.5	59.9	53.4
1995	50.0	20.8	17.4	17.8	16.3	21.4	22.9	24.0	24.8	22.5	22.8	20.2

## **Reference**

CSR Corporation, Systems Analysis Department, 2002: *Eastern Range Instrumentation Handbook*. CSR Corporation, Orlando, FL.